a man-made cage, up to 100 nanometers in diameter, defining a calculated, artificial, environment-isolating cavity that is bioengineered and formed from a plurality of artificially-induced self-assembling purified Clathrin protein molecules,

and

one or more man-made cargo elements calculatedly located within the man-made cavity, wherein at least one of the cargo elements comprises a man-made, artificially configured qubit element that is by design programmable into ~~a plurality of~~ one or more logical states, which states can deliberately entail, promote, enhance, and exploit the properties of quantum coherence, superposition, entanglement, communications, and other quantum phenomena that are not practically used in naturally occurring systems because by definition the latter do not offer the precise control over their fabrication and operation that is required for quantum information processing,

and

one or more of these man-made elements can be calculatedly expressed as non-naturally occurring quantum memory, register, bus, wire, logic gate, communications, error correction, i/o module, encoder, decoder, and other information processing functions not found in nature, enabling the functional basis of a man-made quantum computer.

References re non-naturally occurring appear in the instant patent specification, some of which are enumerated and highlighted below:

0014 "... According to another feature, **the proteins that form the cage can be bio-engineered using commercially-available biotechnology tools** to contain different cargo elements, which makes the invention more versatile and cost-effective than the existing art."

"**0057** Cage 106 can be naturally occurring or **biologically engineered and/or can use synthetic proteins in whole or in part.** Also, the receptor molecules 104a-104f can be naturally occurring or **biologically engineered and/or can use synthetic proteins in whole or in part** to recognize specific cargo elements 102a-102f. Likewise, the adapter molecules 108a-108f can be naturally occurring or **biologically engineered and/or can use synthetic proteins in whole or in part** to recognize and couple to particular receptor molecules 104a-104f. "

"**0082** As mentioned above, naturally in vivo occurring clathrin cages 106 assemble around membranes to form vesicles. Referring again to Figure 1, the adapter molecules 108a-108f couple clathrin proteins 106a-106f to receptor molecules 104a-104f disposed around the periphery of the vesicle 110. **According to the illustrative embodiment, the clathrin cage 106 is formed around the vesicle 110 *in vitro* using synthetic, natural, or mixed lipid monolayers or bilayers and purified receptor 104a-104f and adapter 108a-108f molecules.** For example, in one illustrative embodiment, **the clathrin cage 106 is formed by adding biologically engineered clathrin proteins 106a-106f and adapter molecules 108a-108f, such as AP-2 and AP180, to a PIP2-containing lipid monolayer**. According to one feature of the invention, **the receptor molecules 104a-104f are biologically engineered** to recognize and associate with specific molecules that serve as the cargo elements 102a-102f. According to another feature, the **adapter molecules 108a-108f are biologically engineered** to recognize specific receptor molecules 104a-104f and couple the receptor molecules 104a-104f to the clathrin cage 106."

"**0084** Below pH 6.5, **purified clathrin triskelions self-assemble *in vitro*** into a polyhedral lattice (cages) without vesicles, but typically only form cages at physiological pH in the presence of **stoichiometric quantities of purified AP-1 or AP-2 adaptor molecules or the neuron-specific assembly proteins AP-180 and auxilin.** Recombinant hubs, formed from residues 1074–1675 of the clathrin heavy chain, are trimeric structures that reproduce the central portion of the three-legged clathrin triskelion, extending from the vertex to the bend in each leg, comprising the binding sites for clathrin light-chain subunits. Without light-chain subunits, recombinant hubs self-

assemble reversibly at physiological pH, while hubs with bound light chains self-assemble below pH 6.5, similar to **purified clathrin. Inhibition of hub assembly by light-chain subunits is a key to controlling spontaneous clathrin self-assembly at physiological pH. The mean curvature of baskets (cages without vesicles) is adjustable by the pH level and by other environmental conditions. As can be deduced from the formation of the microcages, a clathrin network can have such a pH-controlled curvature, even in the absence of a membrane bilayer**. In addition, a conserved negatively charged sequence of three residues (23–25) in the clathrin light-chain subunits regulates the pH dependence of hub assembly. Also, two classes of salt bridge (high affinity and low affinity bridges) play a dominant role in driving clathrin assembly. Basket closure depends on the presence of TDD domains (terminal and distal domains). A connection between the proximal and distal domains is not required for curvature, and the TDD themselves can orient the assembling hubs in a favorable angle for polyhedron formation."

"**0086** The heat shock cognate protein, hsc70, helps to regulate the endocytosis aftermath of CCV uncoating and disassembly. In cells overexpressing ATPase-deficient hsc70 mutants, uncoating of CCVs is inhibited in vivo. In a preferred embodiment, an over expression of **ATPase-deficient hsc70 mutants may be applied and hsc70 mutants additionally modified via bioengineering techniques** to inhibit both CCV and non-vesicle cage disassembly, thereby maintaining CCV and clathrin cage integrity in the invention over prolonged periods of time in vivo and in vitro."

"0092 Bovine clathrin heavy chain cDNA encoding heavy chain amino acids 1-1074 (SEQ ID NO: 1) is cloned into the pET23d vector (Novagen) between the NcoI(234) and XhoI(158) sites. Expression of the cloned sequence results in a terminal and distal domain fragments having a C-terminal polyhistidine tag. Hub fragments corresponding to amino acids 1074-1675 (SEQ ID NO: 2) are cloned into vector pET15b (Novagen) between the BamHI(319) and XhoI(324) sites. Expression of the hub fragments produces the proximal leg domain and central trimerization domain of the clathrin hub with an N-terminal polyhistidine tag. Vectors containing the heavy chain and hub domains **are expressed in *E. coli* by induction with 0.8 mM isopropyl-**

B-D-thiogalactopyranoside for 3 hours at 30 degrees Celsius. **Expressed proteins** are **purified** from bacterial lysate in binding buffer (50 mM Tris-HCl (pH7.9), 0.5M NaCl, 5 mM imidazole) in a nickel affinity resin using the polyhistidine tag. **Proteins are eluted with 100 mM EDTA and dialyzed against 50 mM Tris-HCl (pH7.9). Hub fragments are further purified using size exclusion chromatography on a Superose 6 column (Pharmacia)."**

"0127 Using the universal quantum gate, the quantum processor 602 can perform quantum calculations. Further, because the QIP element 100 is formed using a bioengineered protein, the cage 106 is highly scalable. For example, in some illustrative embodiments, multiple cages 106 may be physically linked via molecular addends, but are not limited to such addend types. In other illustrative configurations, multiple cages 106 may be **functionally linked** via photonic, chemical, electromagnetic, electrical and/or quantum (non-classical) interactions, to work and cooperate locally and/or remotely.

In sum, in order to express that the invention requires the hand of man to exist as well as to have novel utility as quantum information processing elements, it is abundantly clear that the inventors have specified in a number of instances in the instant application specification and amended claims terms such as "purified", and "bio-engineered," "man-made" and "non-naturally occurring". And further, to someone or a person skilled in the art it is clear that the constituent components of the instant invention are fundamentally non-equivalent to the all-natural materials cited in A2 and 3, above.

B. The USPTO has issued rejections:

-Per 35 U.S.C.102 (b) of:

I. Claims 1-16, 19-30, 36-37, 42, 45, 47-49, 51-57, and 61-65 as being anticipated by Gelderblom [AIDS, 1991, Volume 5, pages 617-637] which describes a naturally occurring human immunodeficiency virus (HIV).

II. Claims 1-16, 19-30, 36-37, 42, 45, 47-49, 51-60, and 61-65 as being anticipated by Stewart et al. [Current Topics is (sic) Microbiology and Immunology, 1995, volume 199, pages 25-38] which describes a naturally occurring adenovirus;

III. Claims 1, 3, 17, 18, 24, 34, 35, and 38 as being anticipated by Overman, et al. [Biophysical Journal, volume 66, page A394, 1994, poster abstract)

IV. Claims 1, 3, 17, 18, 24, 34, 35, and 38 as being anticipated by Lee, et al. [Science, May 3, 2003, Volume 296, pages 892-895]

-And also per 35 U.S.C.103 (a) of:

V. Claims 1 and 50 as being unpatentable over Zampighi, et al. [Journal of Structural Biology, volume 119, 1997, pages 347-359 in view of Greene, et al. [Traffic, 2000, volume 1, pages 69-75].

All of the rejections cited in B.I-V are discussed and herein disputed, both generally and specifically by the inventors of the instant invention, below.

B.1 As a general statement re items **BI-IV**, above, the USPTO's attention is drawn to these references in the instant invention specification:

"**0004** The superposition or "coherence" state of a qubit is difficult to maintain because interactions with the surrounding environment cause the qubit to rapidly decay into a classical or "decoherent" state, which destroys the qubit's ability to perform computations. Therefore, **a primary obstacle to building a viable quantum computer is maintaining the qubit in its coherent state long enough to do useful work.**"

"**0014** A further advantage of the invention is that it **provides a structure that maintains quantum coherent states long enough to do useful work**. In addition, the invention can maintain quantum coherent states at room temperature, which eliminates the need for elaborate cooling mechanisms."

"**0034** In general, in a further aspect, the invention is directed to a method of forming a QIP element, including the steps of forming *in vitro* from self-assembling protein molecules, such as clathrin molecules, a cage defining a cavity, and locating one or more cargo elements within the cavity. **In one embodiment, the method includes locating at least one qubit, programmable into a plurality of logical states**, within the cavity."

In marked contrast to the above text from the instant application specification, which text is also reflected in the amended claims, no mention or assertion of any kind is made whatsoever by Gelderblom, Stewart, Lee, and Overman that naturally occurring HIV-1 virus, adenovirus, bacteriophage, clathrin and/or quantum dots structured using genetically engineered viruses are capable of maintaining qubits in a coherent state long enough to do useful work.

Critically, environmental interactions affecting all of these cited materials are effectively prohibiting their utility as quantum information processing systems. Only artificially controlled systems can control these damaging interactions, as expressed in the amended claims and as also specified in the instant invention.

Furthermore, the USPTO-cited authors do not even refer to nor describe their respective materials' capacity to function as elements that enable quantum information processing.

In sum, absent any specific references in citations listed in **BI-IV**, above, as to how such a quantum computer could be built using these respective materials and how they would maintain quantum coherence, the USPTO has simply posited its own speculative inference. Absent any basis in science, fact, or demonstrable utility per the cited references, it was speculation on the part of the USPTO to reject in the instant application a number of claims as listed in **BI-IV**, above. In contrast, the amended claims make clear the unique utility of the instant invention, as well as through the repeated use of terms such as "man-made" and "non-naturally occurring" to express that the invention requires the hand of man to exist and to be operated.

B.2. Along similar lines, the USPTO reasoning for rejecting a number of claims per items **BI-IV**, above, is fallacious; because it asserts that similar structures (i.e., having the same morphology) that follow similar laws of physics equates to these structures having identical utility and functionality. This is simply not true.

E.g., the energy generated by a naturally occurring waterfall is due to gravity and follows the formula, $E = mgh$, where g is the acceleration due to gravity. This same formula is functionally harnessed by water pouring though a hydroelectric facility. However, absent the hand of man, no one would reasonably claim that a natural waterfall

has the same functionality and utility as a hydroelectric facility. Simply having a waterfall in an area does not mean it also produces useful work and can light up a nearby town.

Similarly, simply having a naturally occurring HIV-1 virus, adenovirus, bacteriophage, clathrin in a test tube, and/or quantum dots suspended in a genetically engineered virus does not mean that, although they are bound by and can be made to respond to the same natural laws of the universe, including quantum mechanics, they can do useful work and act as a **human-controllable** quantum information processing system, as is expressed in the instant invention specification and in the amended claims, which make repeated use of terms such as "man-made" "precise control", and "non-naturally occurring" to express that the invention requires the hand of man to exist and to have functionality.

The amended claims, e.g., claim 1, further reflect what was stated in the instant patent specification:

"**0012** The invention, in one aspect, **remedies the deficiencies of the prior art** by providing a nanoscale quantum information processing (QIP) element, which may be employed in a scalable quantum information processing platform. A platform according to the invention may be used for example in quantum computing, quantum networks, and quantum cryptography."

"**0032** In general, in another aspect, the invention features a scalable QIP platform that includes one or more embodiments of the QIP elements described above. Preferably, the scalable QIP platform also includes **an encoder** for programming the qubits of at least a subset of the quantum processing elements, and **a decoder** for reading information from the qubits of at least a subset of the quantum processing elements."

"**0035** In general, in another aspect, the invention is directed to a method of forming a scalable quantum information processing platform, including the steps of providing one or more embodiments of the QIP elements described above, **programming the qubits included in one or more QIP elements using an encoder, and reading information from the QIP elements using a decoder."**

B.3. Furthermore, **none** of the above USPTO cited references in **BI-IV, above**, discuss concrete implementation details as to how the various cited authors would construct an actual quantum computer that has novel utility, as is the case in the instant patent specification and amended claims. Accordingly, the USPTO has failed to prove its case that any of its cited references can actually be used to construct a quantum computer, either theoretically or practically. In marked contrast, below are just several how-to examples from the instant patent specification:

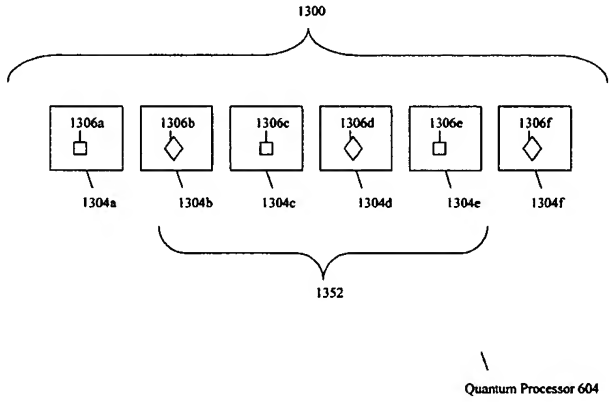

Figure 13

"0134 Figure 13 is a conceptual diagram depicting a chain of clathrin cages within the quantum processor 602 of Figure 6. In one illustrative embodiment, the quantum processor 602 includes a chain 1300 of QIP elements 1304a-1304f enclosing cargo elements 1306a-1306f, respectively, of two different quantum states. In particular, the quantum processor 602 utilizes a small number of identifiable spins placed in a regularly spatial pattern. The first 1304a, third 1304c, and fifth 1304e QIP elements each have a respective first 1306a, third 1306c, and fifth 1306e cargo element. The second 1304b, fourth 1304d, and sixth 1304f QIP elements each have a respective second 1306b, fourth 1306d, and sixth 1306f cargo element. The first 1306a, third 1306c, and fifth 1306e cargo elements are also collectively referred to below as an A molecule. Similarly, the second 1306b, fourth 1306d, and sixth 1306f cargo elements are also collectively referred to below as a B molecule. In one illustrative embodiment, utilizing a quantum cellular automata quantum computing architecture, but the invention is not limited to utilizing

such architectures, the A and B molecules 1306a-1306f have different, identifiable spin species, and for example, the A and B molecules respectively may correspond to a distinctive chemical variant of a nitroxide molecule. In one illustrative embodiment, either the nuclear spin or the electron spin of the A and B molecules represent qubits. In the illustrative embodiment, the QIP elements 1304a-1304f are arranged in alternating linear patterns such that the molecules form a chain configured alternatively, e.g., ABABAB."

"0132 The quantum computer 600 manipulates the quantum information encoded in this spin chain 1300 via global addressing techniques. Thus, in one illustrative embodiment, a qubit is encoded into four spin sites of the cargo elements 1306a-1306f with a buffer space of four empty spin spites between each logical qubit."

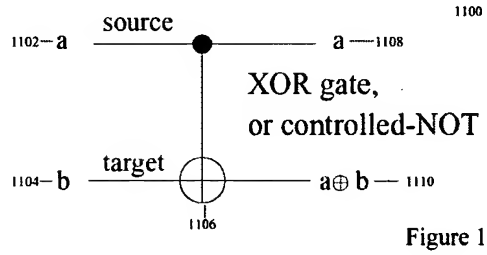

Figure 11

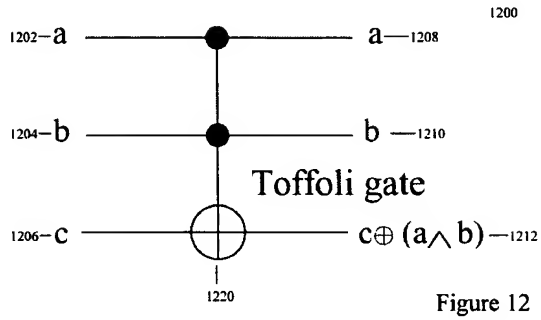

Figure 12

"**0133** To create the quantum gates of Figures 11 and 12, a unitary operator $\hat{A}\frac{U}{f}$ is first realized. Denoting the spin upstate as $|1\rangle$ and the spin down state as $|0\rangle$, $\hat{A}\frac{U}{f}$ is the conditional application of the unitary U to the A qubits in the alternating qubit chain 1300 ABABAB, depending on the state of A's neighboring B qubits. In a preferred

embodiment, the qubits are represented by spin states. Regarding $\hat{A}\frac{U}{f}$, f is the sum of the states of the neighboring B spins. Regarding $\hat{B}\frac{U}{f}$, f is the sum of the states of the neighboring A spins. Thus, if $f = 1$, $\hat{A}\frac{U}{1}$ is the conditioned application of U to all A spins in the alternating chain 1300 which have neighboring B spins that are different from each other. In one embodiment, the I/O module 602 sequences the application of $\hat{A}\frac{U}{f}$ and $\hat{B}\frac{U}{f}$ to generate the single qubit operations and the two-qubit CNOT operations. In particular, to move quantum information across the cargo elements 1306a-1306f through the spin chain 1300, the quantum I/O module 602 applies an alternating pulse sequence of $\hat{A}\frac{NOT}{1}$ followed by $\hat{B}\frac{NOT}{1}$, while the generation of a control-U between two neighboring logical qubits requires a predetermined number of global pulses. The application of the above two pulse sequences results in a quantum CNOT gate within the QIP element 1304a. In a preferred embodiment, the global addressing pulses include electromagnetic field pulses that interact with the qubits. In another illustrative embodiment, ENDOR includes the values of the pulses."

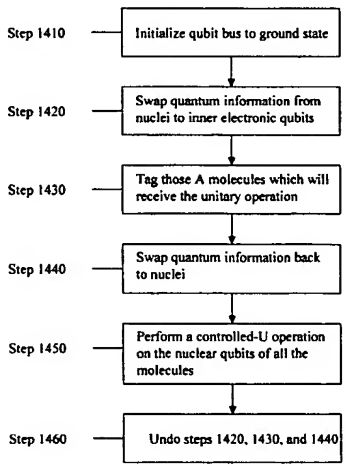

Figure 14

"0134 Figure 14 is a flow diagram depicting exemplary steps performed by the quantum processor of Figure 6 to perform quantum operations. The first step 1410 involves initializing a local qubit bus 1352 to ground state. In a preferred embodiment, the qubits exist within QIP elements 1304a-1304f. In another embodiment, the qubits exist in joined QIP elements 1304a-1304f according to the method of Figure 10. In one illustrative embodiment, the quantum information is stored in the electron spins of the cargo elements 1306a-1306f. In another illustrative embodiment, the quantum information is stored on the nuclear spin of the cargo elements 1306a-1306f. In one illustrative embodiment, this initialization occurs with a spin cooling quantum algorithm to spin cool all of the nuclear and electron spins to the ground state. In another illustrative embodiment, initialization occurs with spin initialization imposed by an external magnetic field."

"0135 Referring again to Figure 13, to execute a unitary operator, the inner cargo elements 1306b-1306e become a local "bus" 1352 for the quantum information stored in the nuclei of the cargo elements 1306a-1306f that act as qubits. In the illustrative embodiment, the cargo elements 1306a-1306f are molecules whose electron or nuclear spin represent quantum information including qubits. In the illustrative embodiment, the algorithm begins in step 1410 by initializing the bus 1352 to the ground state of a cargo element including nuclear spin as a qubit. Because the nucleus is presumed to be a fermion, it possesses ground state spin denoted by $|m_s\rangle = |-1/2\rangle$ for all of the molecules 1306b-1306e that exist in the bus 1352. According to the illustrative embodiment, this initialization occurs with a spin cooling quantum algorithm to spin cool all of the nuclear and electron spins to the ground state. In a particular embodiment, application of RF waves mediate the spin cooling. Subsequent to the initialization, an arbitrary pattern of quantum information is written onto the nuclear spins of the A and B molecules 1306a-1306f within the clathrin cages 1304a-1304f, respectively. The quantum processor 602 then swaps 1420 the quantum information of the first cargo element 1306a from the nuclei to the electron of the first molecules in the local bus 1306b. In the illustrative embodiment, the swap operation 1420 is performed using

multiple CNOT operations using the method described with respect to Figure 11. The quantum computer 600 then tags 1430 the first cargo element 1306a receiving the unitary operation U in $\hat{A}\frac{U}{f}$ by performing a spin-flip on all of the electrons in the bus 1352 in the where the state of neighboring electrons exists in an opposite quantum logic state. The quantum computer 600 then undoes the swapping step 1420 by swapping 1440 the quantum information back into the nucleus of the last cargo element 1304f from the electron of the last cargo element 1306e of the local bus 1352. The quantum state of the information transmission is inferred from the state of the last cargo element 1304f."

"**0136** The quantum computer 600 then performs a controlled-U operation 1450 on the nuclear qubits of all of the cargo elements 1306a-1306f within the QIP elements 1304a-1304f using the electron qubits of the molecules in the bus 1352 as a control. In one embodiment, the quantum processor performs the controlled-U operation essentially as discussed referring to Figure 13. In step 1460, the quantum computer 600 undoes the previous steps to initialize the QIP elements 1304a-1304f for the next global operation 1400. Thus, the quantum processor 602 swaps the information from the nucleus to the electron on the first cargo element 1306a, undoes the tagging 1430 of the adjacent molecules 1306b-1306f, respectively, and then swaps 1440 the quantum information back from the electron of the last cargo element onto the nucleus of last cargo element 1306f. The quantum processor 602 consequently re-initializes the system in the manner described above after performing the global operation $\hat{A}\frac{U}{f}$.

In summary, none of the above USPTO cited references in **BI-IV** discuss concrete implementation details like those set forth in the instant patent application specification. Moreover, the various cited authors do not even contemplate constructing an actual quantum computer that has novel utility, as is expressed in the instant application and amended claims, which make repeated use of terms such as "man-made" and "non-naturally occurring" to express that the invention is expressly constructed for a specific purpose via the hand of man. The USPTO rejection of claims per **BI-IV** in the instant patent specification is thus based on conjecture and theoretical speculation.

B.4. Now to discuss certain issues mentioned in the USPTO claim rejections listed in **BI-IV**, above, in order:

The natural self-assembly mechanics of bio-structures, which is listed as one basis for USPTO rejection of some claims (**see BI, II, and III, above**), is, in fact, a basic feature of nearly all bio-systems from the nanoscale to the macro. There is ample and lengthy precedence of the USPTO awarding numerous patents for inventions that utilize natural self-assembly for forming structures like vesicles and other self-assembling frameworks.

As an example, the following recently issued patents, which are listed on a separate document and herein listed as a reference, all utilize natural self-assembly to form various kinds of biological structures, including vesicles, etc. (A simple search will show hundreds of USPTO issued patents that utilize natural self-assembly to produce manifold structures, including cavities, etc.):

7,112,330, Method for producing yeast expressed HPV types 6 and 16 capsid proteins, Buonamassa, et al., September 26, 2006

7,105,303, Antibodies to hepatitis C virus asialoglycoproteins, Ralston, et al., September 12, 2006,

7,094,409, Antigen arrays for treatment of allergic eosinophilic diseases, Bachmann, et al., August 22, 2006

RE39,229, Binding proteins for recognition of DNA, Choo , et al., August 8, 2006

7,060,291, Modular targeted liposomal delivery system, Meers, et al., June 13, 2006

7,063,860, Application of lipid vehicles and use for drug delivery, Chancellor,et al., June 20, 2006

7,048,949, Membrane scaffold proteins, Sligar, et al. May 23, 2006.

A distinguishing and defining characteristic of the above and other patented systems using self-assembling bio-structures is the clear evidence of the intervening hand